

35t April 4-8 Noise Tests

20160411 - 35t - B.Kirby

Overview

- Reminder of noise issues
- Noise tests to date
- April 4-8 noise tests
 - ~11kHz Correlated Noise Removal
 - Low-noise “everything off” tests - understand best case performance
 - “High-noise state” tests
- Summary and plans

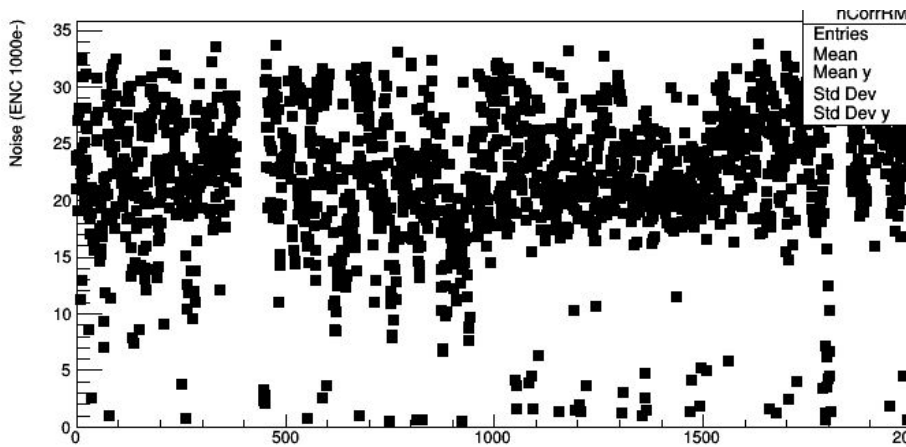
35t TPC Readout - Main Noise Issues

- Two main problems with TPC readout noise (in order of importance):
 - Noise levels are not stable: all FEMB channels have some chance to jump into a “high-noise” state that can only be removed by power-cycling the ASICs
 - Noise levels are high: when the readout is not in a bad state the noise levels are still high

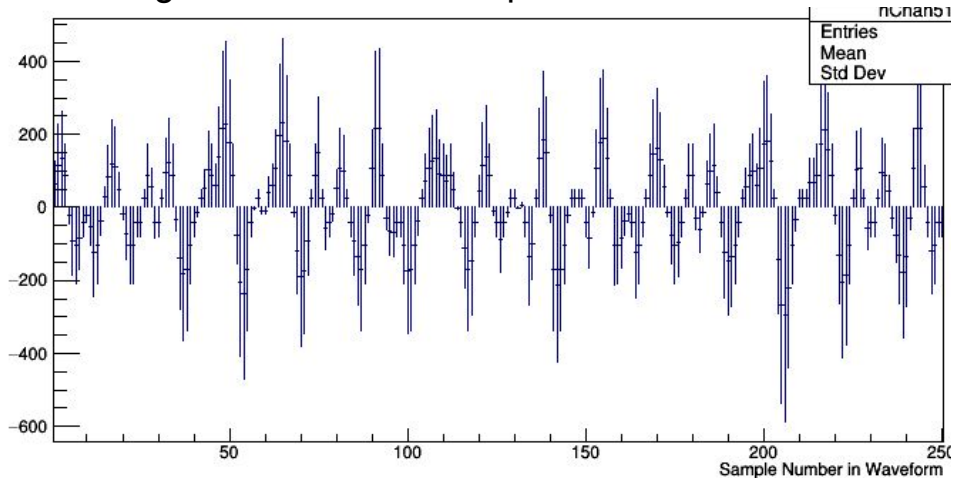
Noise Issues - “High Noise” State

- Two main problems with TPC readout noise:
 - Noise levels are not stable: all FEMB channels have some chance to jump into a “high-noise” state that can only be removed by power-cycling the ASICs (only started after 35t filled)
 - Noise levels are high: when the readout is not in a bad state the noise levels are still high

High-Noise State Measured ENC

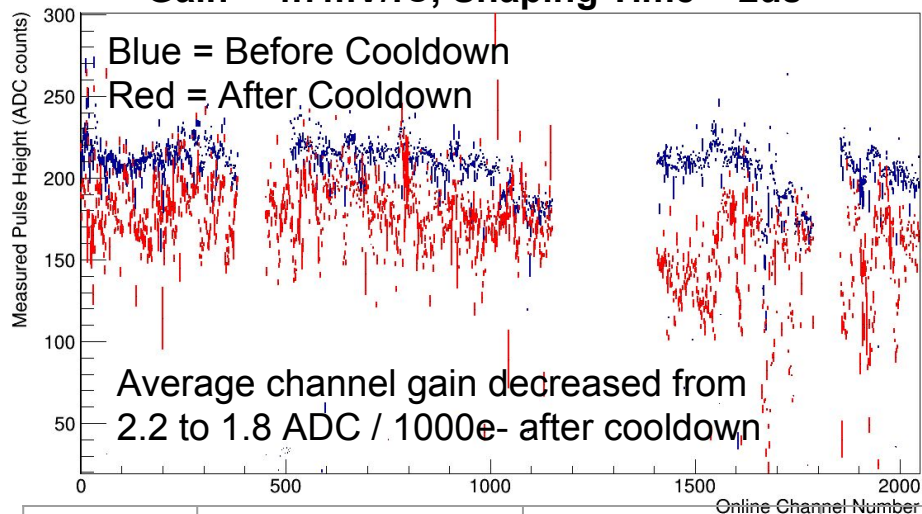


High-Noise State Example Waveform

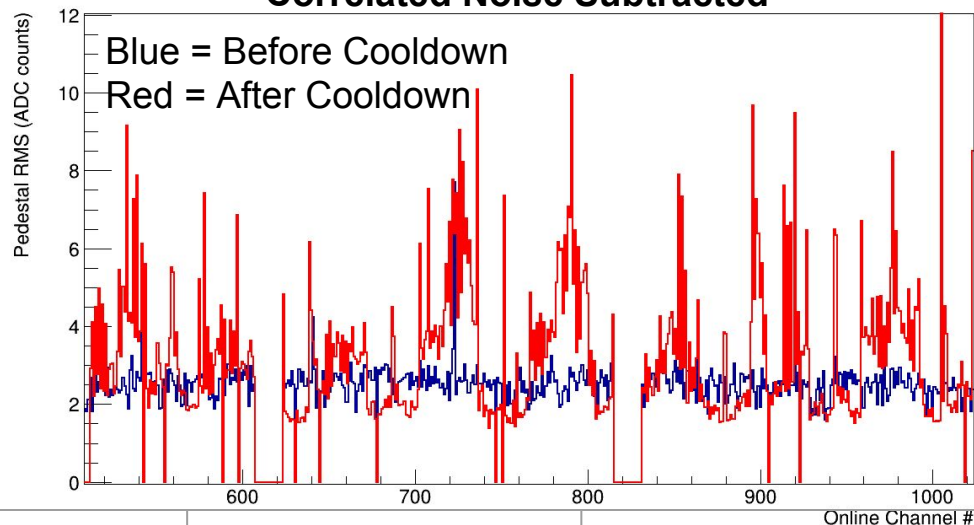


Noise Issues - Noise Levels are High

Measured Pulse Heights for 85mV Pulser Signal
Gain = 4.7mV/fC, Shaping Time = 2us



Measured Pedestal RMS, Correlated Noise Subtracted



Run	State	Collection Noise (ENC)	Induction Noise (ENC)	Collection Noise 11kHz Subtracted	Induction Noise 11kHz Subtracted
8476	Before cooldown	1330 e-	1470 e-	1130 e-	1160 e-
10116	After cooldown	2400 e-	3430 e-	1220 e-	2280 e-

Noise Tests to Date

- Significant work done to understand and reduce 35t noise
- Feb 17 : “Everything off” test
- Feb 18-23 : Stability and configuration scans
 - <https://indico.fnal.gov/conferenceDisplay.py?confId=10711>
- March 4: 2nd “Everything off” test - identified variation in noise between APAs
 - https://dl.dropboxusercontent.com/u/10099840/LBNE/2016_35t/20150304_NoiseHunting.pdf
- March 30-April 4 : Extended single-FEMB stability test
 - ELOGs 8701, 8760
- April 4-8 : Recent noise tests

Noise Tests to Date - Variation Between APAs

- Run 14598 is last run recorded before March 4 noise tests (ELOG 7268)
 - FE-ASIC settings gain = 14mV/fC, shaping time = 3us
- See significant difference in noise levels between APAs (note this run taken with all non-TPC systems on)

Run	APA	Collection Noise (ENC)	Induction Noise (ENC)	Collection Noise 11kHz Subtracted	Induction Noise 11kHz Subtracted
14598	APA0	3400e-	4530e-	2140e-	2510e-
14598	APA1	2180e-	2790e-	1070e-	1950e-
14598	APA2	2950e-	3750e-	1970e-	2630e-
14598	APA3	2130e-	3130e-	1530e-	2890e-

Noise Tests to Date - Non-TPC Noise Sources

- March 4 test: non-TPC systems turned on one at a time to measure contribution to noise, looking at “quiet” APA1

Run	Settings	Collection Noise (ENC)	Induction Noise (ENC)	Collection Noise 11kHz Subtracted	Induction Noise 11kHz Subtracted
14623	14mV/fC, 3us	1910e-	2430e-	610e-	1120e-
14628	14mV/fC, 3us SSPs on	2060e-	2540e-	670e-	1270e-
14629	14mV/fC, 3us Counters in	2060e-	2550e-	680e-	1280e-
14630	14mV/fC, 3us APA bias on	2070e-	2620e-	725e-	1430e-
14663	14mV/fC, 3us Drift on	2160e-	2760e-	740e-	1500e-

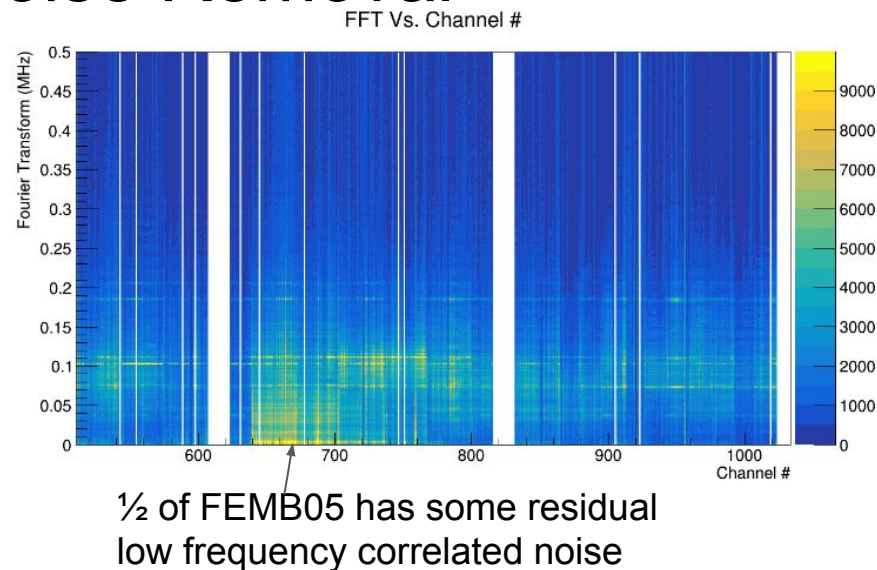
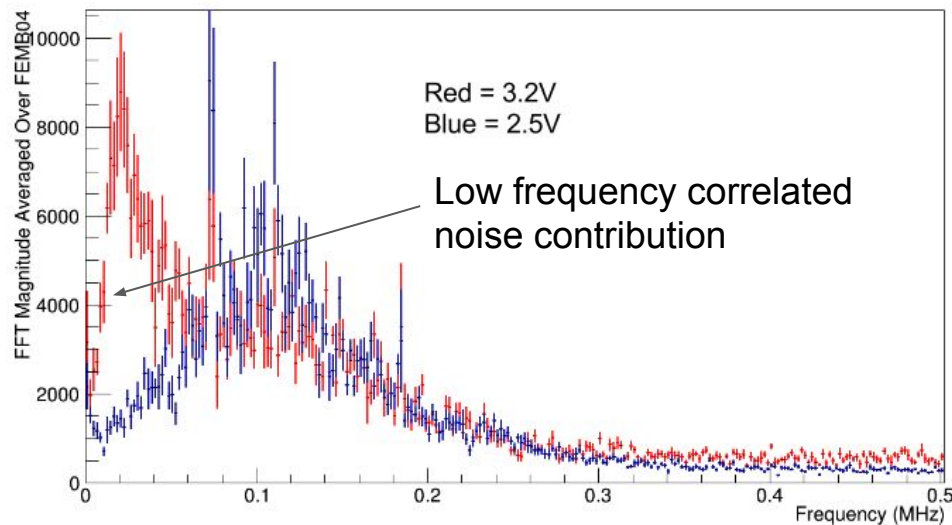
Noise Tests to Date - Extended Stability Test

- During 35t physics run, had significant stability issues with detector randomly going into high-noise state
 - Several different causes: run start, turning on FEMB ASICs, sometimes in middle of a run
 - 3-board ASICs turned off to prevent detector constantly going into “high noise” state
 - Detector noise generally normal for 1-2 hours
 - Problem became worse as drift field increased
- Performed an extended single FEMB stability test at end of 35t physics data-taking
- Only FEMB04 ASICs turned on from March 30 to April 4
 - Drift field at 120kV, wire-bias at nominal values
- High-noise state did not occur at all

April 4-8 Noise Tests

- ~11kHz Correlated Noise Removal
- Low-noise “everything off” tests - what is limiting performance
- “High-noise state” tests - how to induce and remove high-noise state

Low Frequency Correlated Noise Removal

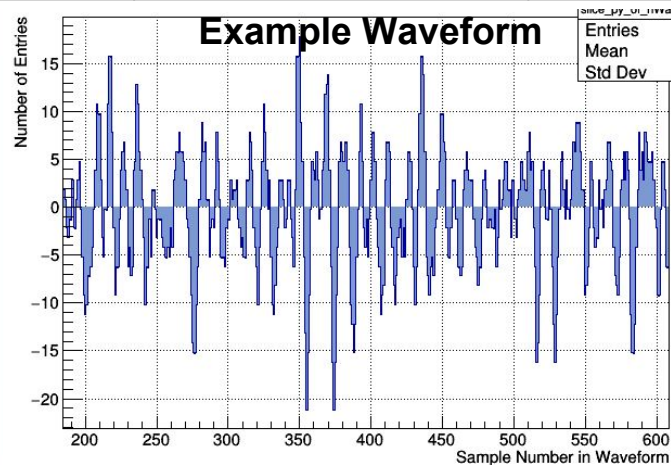
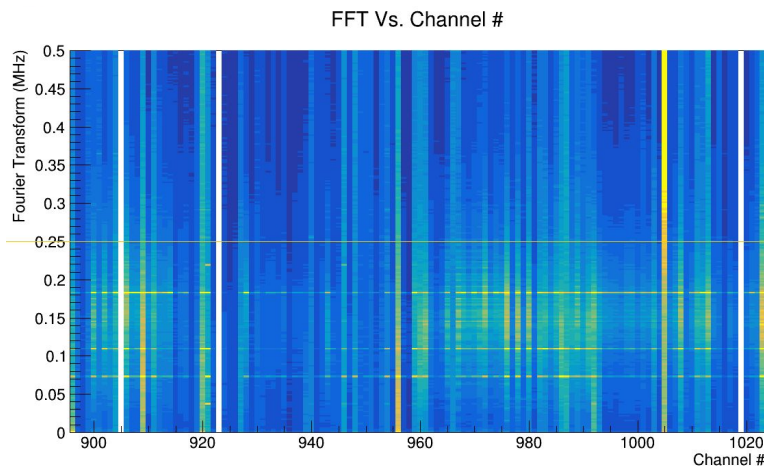


- Test stand work by H. Chen and S. Gao showed that low-frequency correlated noise could be reduced by lowering input voltage to regulator for ASIC VDD
- Removed low frequency correlated noise in 35t detector (ELOG 8738, 8801)
 - Higher frequency correlated modes (>50kHz) remain

“Everything Off” - Low Noise Tests

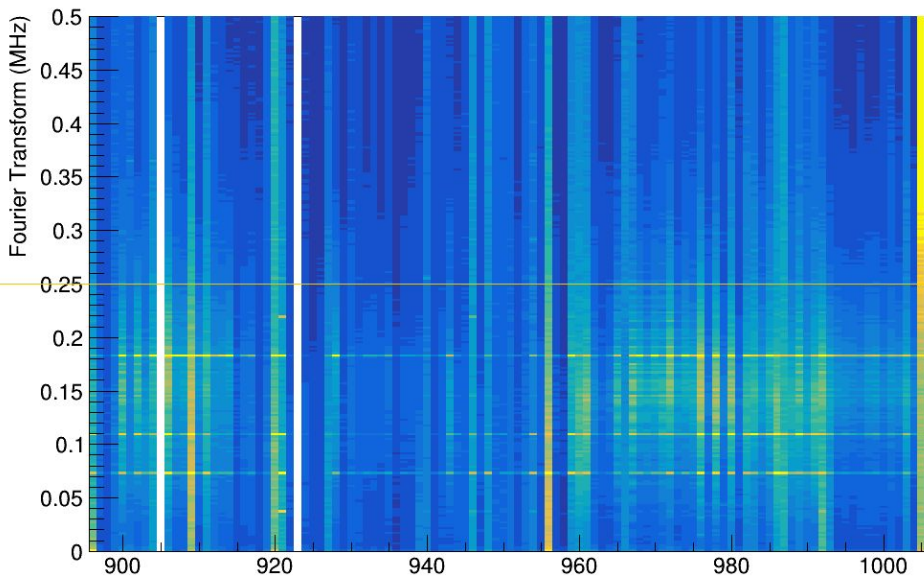
- Repeated previous “everything off” tests, also terminated control cable connectors on flange board, turned off all LV power except to a single FEMB
- Run 18396 - 4.7mV/fC + 2uw - noise dominated by >50kHz modes

Run	State	Collection Noise (ENC)	Induction Noise (ENC)	Collection Noise 11kHz Subtracted	Induction Noise 11kHz Subtracted
18396	Everything Off	1970 e-	2980 e-	1120 e-	2000 e-

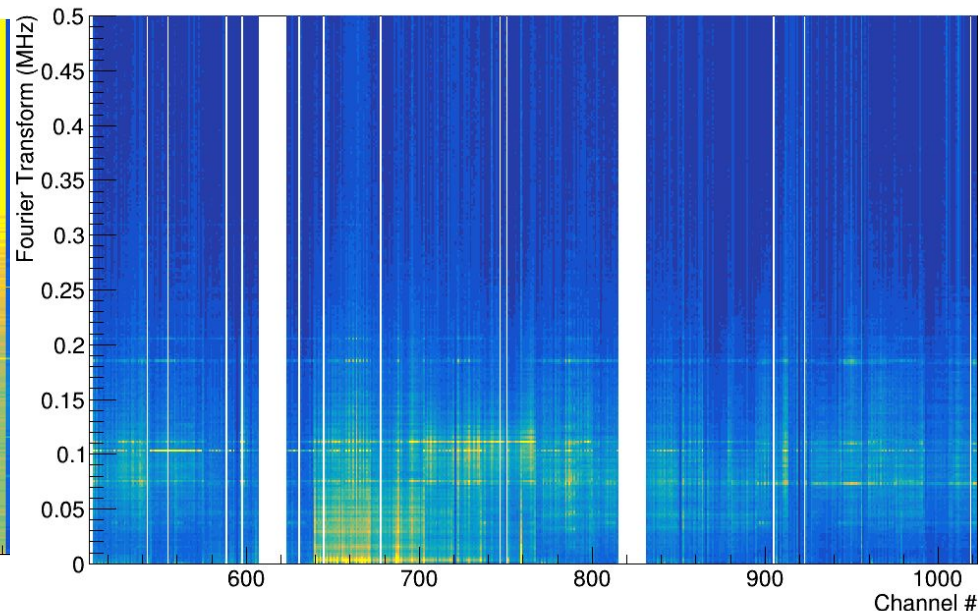


Comparison Of $>50\text{kHz}$ Modes - Multi-FEMBs On

FEMB07 ASICs on Only



FEMB04-07 ASICs on Only

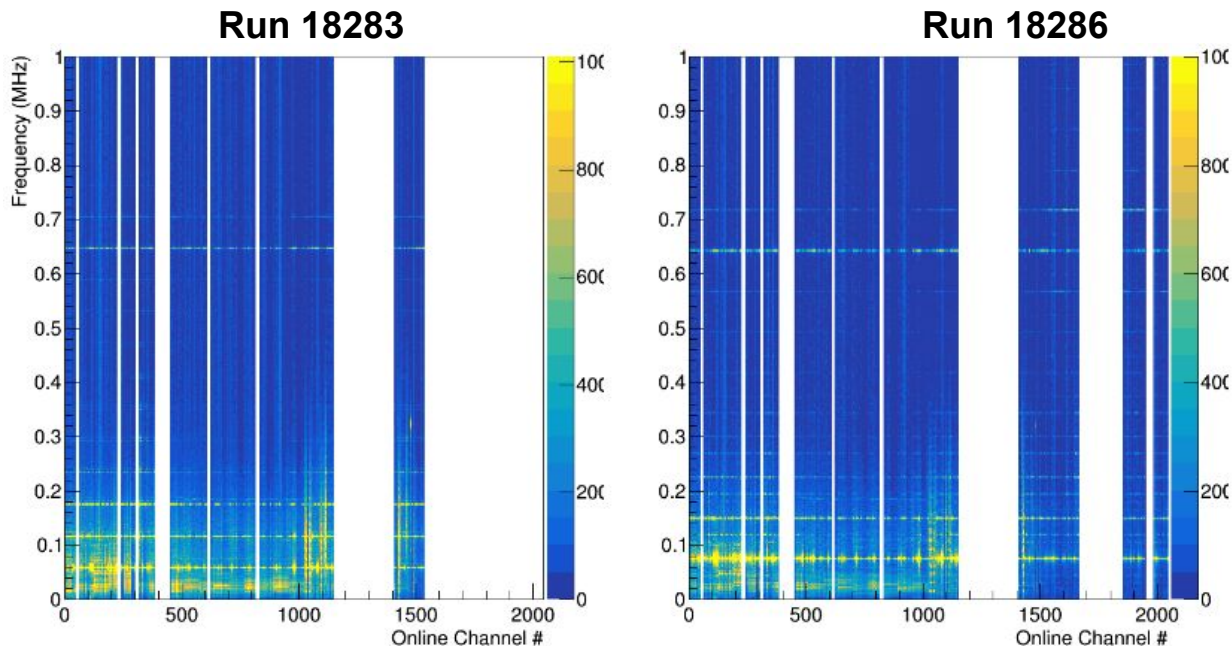


- Turning on ASICs on additional FEMBs increases the number of modes seen in the FFT, consistent across all FEMBs (note this is all on the “quiet” APA)

Adding Noise to the LV Lines

- Tried to inject pulser signal directly into LV cables connectors (ELOG 8767)
 - Pulser running at 50% duty cycle, ~35V and 35MHz into an unterminated coax cable wrapped near the LV cables/connectors
- Noise levels identical between run 18218 (before pulser) and 18222 (after pulser)

High-Noise State >50kHz Modes



- >50kHz dominate during high-noise state, consistent across entire detector
 - Modes seen in waveform data corresponded to modes observed with spectrum analyzer attached to grid plane
- Frequencies shifted between runs (ELOG 8796)

High-Noise State Induction/Removal

- Tried to find a reliable means of inducing high noise state on
 - Injecting pulser signal onto collection plane
 - Ramping wire-bias
 - These were not successful
- Most consistent method for inducing high-noise state was power-cycling ASICs on FEMB00 or FEMB12
 - Not 100% probability
 - Not clear why these boards are susceptible
- Generally only consistent method to get detector out of high noise state is to power-cycle FE + ADC ASICs
- On April 8, induced high-noise state by power-cycling FEMB12
 - Monitored high-noise state with spectrum analyzer attached to grid plane
 - Turned off all digital logic: FPGAs, oscillators, ADCs stop sampling with FPGA off
 - High-noise state persisted, only went away after power-cycling ASICs on FEMB12

Summary and Plans

- Studied main TPC noise issues:
 - Low-frequency correlated noise removed, but did not improve channel noise levels
 - Channel noise levels generally dominated by >50kHz modes
 - High-noise state hard to reliably induce, generally requires power-cycling ASICs to remove
 - High noise states does not seem to be caused by digital logic
- Significant variation in noise levels and stability between APAs
 - 4-board APA had lowest noise levels, FEMB04 ran for 6 days without high-noise issue with drift + wire bias on
 - 3-board APA ASICs had to be turned off during data-taking to obtain quasi-stable noise levels
- Would like to run a few remaining noise tests remotely
 - Take data with individual ADC channels turned off
 - Terminate HV inputs into the cryostat, check noise levels
- Suggestions?

Backup